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PORTLAND, OREGON, MEETING, JUNE 19, 1925

The 134th regular meeting of the American Physical Society will be held in Portland, Oregon, at the Laboratory of Physics of Reed College, in affiliation with the Pacific Division of the American Association for the Advancement of Science. The meeting of that Association includes a research conference, Wednesday, June 17, and other meetings and excursions extending through Saturday, June 20. The meeting of the American Physical Society will be on Friday, June 19, the first session beginning at 10 o'clock.

Other meetings for the current seasons are as follows:

135. November 27-28, 1925. Chicago.
136. December 28-31, 1925. Kansas City. Annual Meeting.
137. February 26-27, 1926. Montreal.
138. Pacific Coast Section. Place to be determined.
139. April 23-24, 1926. Washington, D. C.

D. L. WEBSTER
Secretary, Pacific Coast Section.

PROGRAM

FRIDAY, JUNE 19, AT 10 O'CLOCK

1. Quantum theory of the number of beta-rays associated with scattered x-rays. G. E. M. JAUNCEY and O. K. DEFOE, Washington University, Saint Louis.—A. H. Compton and A. W. Simon (Phys. Rev. **25,** 306, 1925) have recently measured the ratio of the number of recoil electron tracks to that of the photo-electron tracks in a Wilson cloud apparatus. For short wave-length x-rays the experimental ratio was found equal to σ/τ as predicted by the theory of Compton and Hubbard (Phys. Rev. **23,** 439, 1924). For the long wave-lengths, however, the experimental ratio is distinctly smaller. In the present paper a correction factor is applied to σ/τ by taking into account the motion and the binding energy of the scattering electron in its Bohr orbit, as done by Jauncey (Phys. Rev. **25,** 314, 1925), and also the minimum energy which the recoil electron must have in order to produce a visible track. Assuming a minimum energy of 630 volts for a recoil electron to produce a visible track, the correction factor for a primary wave-length of 0.71A is 0.36, thus making the theoretical value of the ratio of recoil to photo-electron tracks 0.097 as against an experimental ratio of 0.10. For other wave-lengths the agreement is equally good.

2. X-rays scattered by molybdenum. P. A. Ross, Stanford University.—Using an ionization spectrometer and a standard water-cooled molybdenum Coolidge tube, the radiation scattered by the molybdenum cathode cup of the tube itself has been measured at 110° and 160° scattering angle. The shift of the modified line at 110° was $.035 \pm .002$A. The theoretical value is .0345A. At 160° the measured shift was $.047 \pm .002$A and the computed value .0469A. The unmodified line was completely obscured by the intense fluorescent line coinciding with it and making any estimate of relative intensity impossible. Radiation scattered from the glass was measured by slightly displacing the tube so that the line of slits just missed the cathode cup. The glass scattering was small compared with that by the cathode. Using a standard tungsten Coolidge tube and the same method of procedure the scattering of tungsten K radiation from molybdenum was observed. At 160° scattering angle the tungsten $K\alpha$ line was shifted by $.047 \pm .001$A. The ratio of intensity of modified to unmodified line was .10 but this was probably too low due to fluorescence of the thin coating of tungsten deposited on the cup.

3. Measurement of the light scattering coefficient of some saturated vapors. SCOTT EWING, University of California.—This investigation is an attempt to verify the theory of light scattering by measuring the scattering coefficient and comparing it with the theoretical value which can be calculated from a knowledge of the compressibility and refractive index of the medium and the wave-length of the incident light. The saturated vapors of ether, benzol, chloroform, ethyl alcohol and methyl alcohol were used as scattering media. The effective wave-length of the incident light was calculated by measuring the effectiveness of the different wave-lengths of the source (a locomotive headlight) in blackening a photographic plate, and assuming that the scattering coefficient varies inversely as the fourth power of the wave-length, which is true except for the small effect of dispersion. The scattering coefficient was measured by making a photographic comparison of the intensity of the light scattered at right angles, with the incident intensity. The results agree with the theory within the limits of experimental error. The data may be used to make an estimate of the *number of molecules per cubic centimeter* and the result obtained is $(2.68 \pm .04) \times 10^{19}$.

4. Organic absorption media as color screens in the ultraviolet. THOS, M. DAHM, University of Idaho.—Examination of ultraviolet absorption spectra of many organic compounds in aqueous solution shows that on the edges of the very deep and broad absorption bands frequently found, the absorption coefficient K fits approximately the exponential curve $K=K_1e^{a(\nu-\nu_1)}$ throughout a range of frequency ν to ν_1. If such adjustment of concentration or length of cell is made that the transmission $I/I_0(=e^{-kcx})$ has a value $e^{-1}=.37$ for some spectrum line in the range ν to ν_1, the transmissions of lines on the high absorption side will fall off more rapidly than the absorption coefficient rises, and will rise less rapidly on the other side than the coefficient falls. A geometrical series of decreasing concentrations will shift a given percentage of transmission from line to line in arithmetical series. Also the "gradation" of absorption will be the same in the whole series of photographs. Throughout this range of frequencies, the length and location of which is characteristic of the material, $a=(1/k)\ (dk/d\nu)=d(\log k)/d\nu=-d(\log c)/d\nu$. The substance can be used equally well to limit the spectrum at all points in this range by a proper choice of concentration. The "gradation constant" a is in many cases so large that a given line of the mercury spectrum may be transmitted with 20 percent of the unabsorbed strength and the next strong line with less than 0.2 percent. In addition, many substances transmit at proper concentration a characteristic band of high frequency lines with practically no light for a wide range on both sides.

5. Series and multiplets in sulfur and chlorine. J. J. HOPFIELD, University of California.—Some time ago the author published some new sulfur series, (Nature **112,** 437, 1923). These have been rechecked. The frequencies are given by the following equations:

$$\nu=83554-N/(n+1.05086-0.13386/n+0.05425/n^2)^2$$
$$\nu=83554-N/(n+0.53341+1.06794/n-0.82152/n^2)^2$$

The series' head is indicated only for the highest members of the triplets. By the use of these series the unassigned lines of sulfur (Fowler's Report, p. 170) have been arranged into series. The stronger members of these series lie in the infrared and have not been observed. Two multiplets whose shortest wave-lengths are 1381.60 and 1473.00 respectively have been found in sulfur. They each contain the fundamental triplet differences and are attributed to a two electron transition. Strikingly similar groups have been found in chlorine which has lost an electron (Phys. Rev. **23,** 766, 1924). The shortest wave-lengths of the triplets are 789.03, 834.83, 888.18, and that of the multiplet like the 1381 group of sulfur is 1063.88. By analogy with S_I the ionizing potential of Cl_{II} is provisionally calculated as 18.32 volts; hence that of Cl_I is about 9.16 volts.

6. Series spectra of B_{II} and C_{III}. I. S. BOWEN and R. A. MILLIKAN, California Institute of Technology.—By the methods previously reported in our development of hot-spark spectrometry, the following term values of B_{II} have been determined: $2S=194325.9$; $3S=66665.1$; $2P=120929.4$; $3D=48410.3$; $3s=72930.8$; $4s=36655.5$; $2p_1=165343.9$; $2p_{2,3}=165362.7$; $3p_1=59006.5$; $3p_{2,3}=59010.0$; $3d=52054.2$; $4d=28640.4$; $4f=27800.0$; $5f=17795.7$. The following term values of C_{III} have also been found: $2S=375463.1$; $2P=273111.0$; $3s=146197.2$; $2p=331939.2$; $3p_1=124685.8$; $3p_2=124698.6$; $3p_3=124704.1$; $3d=114387.2$; $4f=62600$.

7. Emission from the Bunsen flame. JOSEPH W. ELLIS, University of California, Southern Branch.—Using a new self-registering infrared spectrograph with two quartz prisms in Littrow mounting, the 2.7μ emission band of the Bunsen flame appears widely resolved with maxima at 2.58 and 2.76μ. A weaker doublet at 1.79, 1.99 and a still weaker broad band at 1.40 appear. These regions of emission correspond in general to numerous weak maxima found by Paschen in 1894 who identified them all except the long wave-length part of the first mentioned band with water vapor since they also occur in the oxyhydrogen flame. Barker's assumption that the primary separation of the 2.7 carbon dioxide band is not a regular infrared doublet is here supported by the fact that a corresponding emission doublet would have a separation equal to that observed between the

water vapor and carbon dioxide bands in this region. Calculation of the bunsen flame temperature from Barker's 4.4 emission and absorption doublet gives a value consistent with measurements. The correctness of his assumption that all of these bands, except the 2.7μ region, are due to water vapor seems doubtful, since there are no emission bands corresponding to the strongest of all water vapor bands near 6μ. Their regular diminution of intensity and the gradual deviation of their frequencies from a straight line relation seem to identify these bands, as well as the strong 4.4μ band observed with longer wave-length spectrographs, as due to successive vibrational-rotational states of the CO_2 molecule. This assumption is further supported by the fact that the law deduced for a Bjerrum doublet, $\sqrt{T}\lambda_1\lambda_2/(\lambda_1-\lambda_2)$ = a constant, when applied to the primary separation in the CO_2 absorption doublet at 2.7μ recently measured by Barker, predicts an emission separation of the observed amount. The Bunsen flame temperature was taken as 2028°K, an average of determinations by Féry and by Schmidt. The difference in the frequency separations of the double bands suggests different physical states for the emitting molecules.

8. On the thermo-electric properties of pure metals and alloys. A. E. CASWELL, University of Oregon.—Analysing data used in the preparation of the International Critical Tables, the author shows that the thermo-e.m.f. between a compressed metal and the same metal when uncompressed, can generally be represented by an equation of the form $E=apt(1+bp)\ (1+ct)$. Exceptions are aluminum, iron and tin. Apparently aluminum undergoes a quasi-allotropic modification under pressures in excess of 6500 kg/cm². The effect of pressure upon the concentration of free electrons in a metal is discussed. Changes in their thermo-electric properties as metals pass from the solid into the liquid are examined and deductions drawn therefrom on the basis of electron theory. The author also shows that in certain cases it is possible to predict the thermo-electric properties of an alloy from those of its constituents, especially when the pure metals unite in definite proportions, e.g. Ag-Pd alloys.

9. Parasitic thermo-electric forces in homogeneous metals due to a changing temperature gradient. E. D. MCALISTER, University of Oregon (introduced by W. P. Boynton).—When the ends of an apparently homogeneous wire are attached to a galvanometer and a Bunsen flame is used to heat a section of the wire to incandescence, no deflection is observed, unless the wire has been maltreated mechanically or is a non-homogeneous alloy. However, when the glowing part is caused to move along the wire by moving the flame a current is observed to flow (large in the case of Fe and Ni), and the direction of the current is reversed when the direction of motion of the glowing part is reversed. Data on a considerable number of substances are presented and the relation to electron theory discussed.

10. Thermo-electric effects due to mechanical treatment; Benediks effect. L. J. NEUMAN, University of Oregon (introduced by Professor W. P. Boynton).—The end or central sections of annealed wires of Fe, Cu, Ni, Pb, Al, constantan, german silver, brass, nichrome, fuse wire and manganin were rolled, thus altering the crystalline structure. Thermo-electric powers as high as 2.6 microvolts per degree were obtained between the rolled and unrolled sections. The sign of the e.m.f. was not the same for different metals. Several experiments were carried out for each metal, all of which gave consistent results. In some cases the temperature vs. e.m.f. curve takes the form of a parabola. The e.m.f. from such a junction changes markedly with the amount of rolling and in some cases finally reached a maximum value and decreased. The influence of the length of the transition section between the original and rolled portions has been studied but no consistent results secured. In all of this work pressure and soldered joints were eliminated because in many cases such contacts were found to produce e.m.fs. of considerable magnitude. In some instances the thermo-electric properties produced by rolling are not completely eliminated by re-annealing the specimen. This seems to indicate the presence of a Benedicks effect; however results so far obtained are not sufficiently consistent to warrant definite conclusions. The experiments are being continued.

11. Thermal conductivity of some metals at high temperatures. M. F. ANGELL, University of Idaho.—A continuation of some work done several years ago. The metal in form of a long hollow cylinder is heated electrically, by a heavy current sent through it, and heat flow midway between the ends being assumed radial. The heat flow is calculated from resistance and current at a steady state. Temperatures are taken midway between the ends, upon the axis of the cylinder and at the surface, and thus the thermal conductivity determined. As temperatures inside and out differ only a few degrees and as the bar may be held at any temperature, complete curves are obtained for thermal conductivity from 50 degrees C to the melting point. Data are given for aluminum, copper, nickel, and zinc.

12. Extension of bar method of measuring specific heat. MARCUS O'DAY, University of California.—Measurements of thermal and electrical properties of metals to be of theoretical value should all be made on the same sample under similar conditions or else all on single crystals. By sending a heavy current of proper magnitude through a bar whose ends are kept at zero temperature, electrical and thermal conductivities, their coefficients, and the Thomson effect can all be measured. By use of a double potentiometer, the thermo-electric power of the sample against the copper wire of the thermocouples can be measured. If the temperature of the middle of the bar is taken before the steady state is reached, the diffusivity is equal to $[(2L)^2/\pi^2 t] \log [\theta_m/(\theta_m-\theta)]$ and the specific heat is equal to $.00299\pi^2 I^2 Rt/M\theta_m \log[\theta_m/(\theta_m-\theta)]$ where $2L$ = length, R = resistance, M = mass of bar, θ_m = temperature of middle at any time t measured from moment circuit is closed, θ_m = value of θ in the steady state, and I is proper value of current to compensate for heat loss. No difficulty attends the measurement of these quantities but appreciable error is introduced if the temperature of the ends changes. Corrections for this together with results of measurements of the above effects now in progress on Sn, Sb, and Zn will be published shortly.

13. The effect of reverberation upon the quality of speech. VERN O. KNUDSEN, University of California, Southern Branch.—Speech articulation tests are being conducted to determine the improvement in the quality of speech in auditoriums as a result of reducing the reverberation. The results obtained in several auditoriums, having approximately the same volumes and shapes but different times of reverberation, are tabulated below. The percentage articulation in each case is the average of observations made at essentially all parts of the auditorium.

			Percent articulation		
Audit.	Volume	Reverb.	Word	Vowel	Consonant
A	320,000ft³	7.5 sec.	44.0	88.0	65.4
B*	280,000	5.3	56.3	92.0	73.0
C	310,000	5.0	64.5	97.0	79.0
B**	280,000	3.0	82.2	99.8	88.5
D	270,000	2.8	84.8	99.6	91.7

* Before correction **After correction

Tests in a room having a volume of 4096 ft³ and a variable reverberation, controlled by bringing in different amounts of hairfelt, show that as the time of reverberation was reduced from 5.01 sec. to 0.60 sec., the word, vowel and consonant articulations increased, almost uniformly, from 51, 94 and 71 percent to 92, 99 and 96.5 percent respectively.

14. Design of an acoustic oscillograph. S. H. ANDERSON, University of Washington.—An instrument has been designed of a purely mechanical type in which only the natural frequencies of the diaphram on which the sound waves impinge need to be considered in the calibration, and hence a comparatively simple calibration curve is obtained. Diaphrams of mica, clamped at the edge, have been found to be the most satisfactory. In the investigation previously reported, the natural frequency of the first mode of vibration of diaphrams 5 cm in diameter seemed to be nearly independent of the thickness. Further work with carefully selected samples of different diameters

and thickness shows that for a given diameter the natural frequency is a linear function of the thickness. Assuming Kennelly's equation $2\pi n_0 = \sqrt{s/m}$, the stiffness coefficient s is found to vary directly as the square of the thickness. The natural frequency is also a function of the diameter, increasing rapidly with a decrease of diameter. From this work it will be possible to predict the dimensions of a diaphram for any specified frequency. It is desirable to select a diaphram whose natural frequency is higher than that of any vibromotive force applied.

15. An anomalous sound absorption coefficient. S. H. ANDERSON, University of Washington.—The time of reverberation of sound in the auditorium of Anderson Hall (new Forestry Building) was found to be 70 percent of that required by the simple Sabine equation. The construction materials being the same as in rooms where the equation holds, an explanation was sought in the type of construction. The ceiling is supported by five steel trusses encased in wood, the crown of each truss being 16 feet below the peak of the ceiling. The apparent coefficient of absorption of the wood covering the trusses, computed from the observed time of reverberation, was found to be 0.114, while the accepted value is 0.061. A reasonable explanation is that the mean free path of the sound waves is less and the number of reflections per second greater than in a simple room of the same volume, as the low hanging trusses divide the upper part of the room into six compartments. Sabine's exact equation $t = (p/v)(1/a)\log[(p/v)(A/aVE)]$, shows that t is a function of p/v, the number of reflections per second.

16. The ratio of intensity of the Compton lines. P. A. Ross, Stanford University.—The spectrograms of scattered x-rays taken by the writer alone and in collaboration with D. L. Webster have been studied by means of a photographic densitometer. This has permitted the determination of the intensity ratio of modified to unmodified line (see last column of Table) for various scattering materials and also more precise measurement of the magnitude of shift due to the more accurate determination of the center of gravity of the lines.

Scattering substance	Incident radiation	Scattering angle	Shift (10^{-3}A)	Ratio of intensities
graphite	Mo Kα	30°	3. $\pm$1	0.2
		60°	12.0$\pm$0.1	0.95
		90°	23.6$\pm$0.3	1.7
aluminum	Mo Kα	90°	24.4$\pm$0.1	0.7
aluminum	Mo Kβ	90°	24.2$\pm$0.1	1.0
sulfur	Mo Kα	90°	24.0$\pm$0.5	0.29
copper	Mo Kα	90°	24.4$\pm$0.2	0.32
silver	Mo Kα	90°	23.8$\pm$0.2	0.21
lead	Mo Kα	90°	24.0$\pm$0.2	0.024

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17. The quantum analysis of new nitrogen bands in the ultraviolet. J. J. HOPFIELD and R. T. BIRGE, University of California.—A group of strong bands, degraded to the red, extending from λ1354 to λ1854, appears in purified nitrogen, at 0.003mm pressure, arc discharge, using a long tube and flowing gas. The thirty observed bands (of which seventeen have previously been recorded by Lyman) have in general the customary intensity distribution and thus indicate definitely the correct assignment of vibrational quantum numbers. The resulting equation is $\nu = 68{,}956.6 + (1681.45n' - 15.25n'^2) - (2345.16'' - 14.445n''^2)$, where n' varies from 0 to 3 only, and n'' from 0 to 9. The average (obs. $-$ calc.) is 0.1A. Contrary to expectations, the progressions occurring in this formula have no relation to any other analyzed group of bands, so that the chemical origin of the group is not definitely known. The usual nitrogen groups occur with great intensity on the spectrograms, and there are also a number of additional new bands (or at least hazy lines) between λ950 and λ2100, but no consistent numerical relationships have as yet been found. Hence the hitherto assumed fundamental group of nitrogen bands in this region of the ultraviolet seems to be missing.